Background:
The periodic table can be classified into metals, nonmetals and metalloids. The characteristics of these groups vary greatly. Metals tend to be ductile, malleable, have a metallic luster and are conductors of heat and electricity. Nonmetals tend to be non-lustrous, brittle and poor conductors of heat and electricity. Ductile means that an element has the ability to be drawn into a wire. Copper is used in wiring because it is both ductile and conductive. Malleable means that an element has the ability to be hammered into thin sheets while luster means the element is shiny. Silver and gold are both malleable and lustrous, excellent properties for using these elements in jewelry. Metalloids share some characteristics of both metals and nonmetals. For example, silicon has luster and looks like a metal but does not conduct heat or electricity like a metal. Silicon is classified as a semi-conductor since it will conduct electricity better than a nonmetal. The properties of silicon make it an excellent choice for use in electronic devices.

Table 1: Lead, Tin, Carbon, Silicon
1) Take a magnet and pass over each element. Record results into table below.
2) Take a conductivity tester and test each element. Record results into table.
3) Take the strips of lead and tin. Gently bend each. Do not break them! Which is more malleable: lead or tin? ________________________

<table>
<thead>
<tr>
<th>Element</th>
<th>Color</th>
<th>State (S,L,G)</th>
<th>Metal, Metalloid Nonmetal</th>
<th>Magnetic Yes or No</th>
<th>Conductive Yes or No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lead</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tin</td>
<td></td>
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<tr>
<td>Carbon</td>
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<td></td>
</tr>
<tr>
<td>Silicon</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2: Iron, Zinc, Nickel, Copper
1) Take a magnet and pass over each element. Record results into table below.
2) Take a conductivity tester and test each element. Record results into table.
3) Take the strips of iron and zinc. Gently bend each. Do not break them! Which is more malleable: iron or zinc? ________________________

<table>
<thead>
<tr>
<th>Element</th>
<th>Color</th>
<th>State (S,L,G)</th>
<th>Metal, Metalloid Nonmetal</th>
<th>Magnetic Yes or No</th>
<th>Conductive Yes or No</th>
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</thead>
<tbody>
<tr>
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<tr>
<td>Nickel</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Copper</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

4) What is meant by the word “ductile”? ________________________

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5) Which element appears to be very ductile? ______________________________

6) Are the elements in the same period or family? __________________________

7) Which element appears prone to rusting? _______________________________

Table 3: Sulfur, Aluminum, Silicon, Magnesium
1) What is meant by “luster”? ___________________________________________
2) Which element has a high degree of luster? _____________________________
3) Which element appears to be most nonmetallic? _________________________
4) Carefully run a magnetic across the outside of the container. Check if the element follows the magnet. Record results into table below. Do not open the containers. Observe and record color and state of element. Classify.

<table>
<thead>
<tr>
<th>Element</th>
<th>Color</th>
<th>State (S,L,G)</th>
<th>Magnetic Yes or No</th>
<th>Metal, Nonmetal, Metalloid?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sulfur</td>
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<tr>
<td>Aluminum</td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>Silicon</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Magnesium</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 4: Cadmium, Mercury, Zinc
1) Which element is liquid at room temperature? _________________________
2) Are these elements in the same period or same family? _________________
3) Would these elements be classified as metals or metalloids? _____________
4) Which element appears to be most lustrous? __________________________

Table 5: Helium, Nitrogen, Oxygen
1) Would these elements be classified as metals or nonmetals? ______________
2) Which of these elements are in the same period? ______________________
3) What state are these elements in at room temperature? ________________

Table 6: Hydrogen, Nickel, Argon, Gallium
1) Which elements appear to be metals? __________________________________
2) Which elements appear to be nonmetals? _______________________________

Conclusion:
1) An element is ______________________ if it can be drawn into a wire.
2) Elements that are ______________________ can be hammered into thin sheets.
3) What two properties of copper make it desirable for use in wiring?
   and
4) What two properties of silver and gold are desirable for use in making jewelry?
   and
5) What class of elements are brittle and poor conductors of heat? __________
6) All metals are magnetic. Circle your choice: True or False_______________
7) Most metals are __________ (solids, liquids or gases) at room temperature.
8) Most nonmetals are __________ (solids, liquids or gases) at room temperature.
9) Copper is sometimes coated on the bottom of cookware. What property of copper makes it desirable for this use? ________________________________
**Teacher Notes: Metals, Nonmetals and Metalloids**

**Teaching Notes:**
This lab is used as an introduction to terminology and general differences between metals and nonmetals. No lecture or discussion is needed before doing this activity. I prefer sample bottles with screw on lids. I then place the label around the container / lid area to detour opening of the sample bottles.

**Lab Day:** Approximately 30 minutes
Students read background then answer conclusion questions 1-5. Students are then dismissed to lab. Students walk to each lab station and answer questions or complete chart for that table. Students turn in paper before leaving class.

**Table 1:**
Magnet and Conductivity Tester
(The testers used in this lab were the student conductivity testers from Flinn Scientific.)
Test tube or sample bottle containing: Lead, Tin, Carbon, Silicon
Metal strips of: Lead and Tin
Petri dish of: Silicon pieces and carbon
(Carbon can be used as a conductor as in a rod in a dry cell. Carbon used here nonconductive.)

**Table 2:**
Magnet and Conductivity Tester
Test tube or sample bottle containing: Iron, Zinc, Nickel, Copper
Metals strips of: Iron, Zinc, Nickel, Copper
If strips are not labeled, take a black permanent marker and write names on strips.

**Table 3:**
Magnet
Test tube or sample bottle containing: Sulfur, Aluminum, Silicon, Magnesium
(The sulfur bottle should be tightly sealed. Be aware of any student with a sulfur allergy.)

**Table 4:**
Test tube or sample bottle containing: Cadmium, Mercury, Zinc
The Mercury used here is one drop sealed in an acrylic block.

**Table 5:**
Test tube or sample bottle: Helium, Nitrogen, Oxygen
Confession: They are empty sample bottles labeled Helium, Nitrogen and Oxygen!

**Table 6:**
Test tube or sample bottle: Hydrogen, Nickel, Argon, Gallium
Confession:
Argon and Hydrogen are empty sample bottles labeled Argon and Hydrogen!

If a student asks if hydrogen and argon are actually in there I reply “If you can tell me a test to identify each gas, then I will answer”. This gets them thinking and often to a discussion about hydrogen and oxygen tests using wooden splints.

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Metals, Nonmetals and Metalloids Lab

NAME: ___________________________ DATE: __________ PERIOD: _______

Background:
The periodic table can be classified into metals, nonmetals and metalloids. The characteristics of these groups vary greatly. Metals tend to be ductile, malleable, have a metallic luster and are conductors of heat and electricity. Nonmetals tend to be non-lustrous, brittle and poor conductors of heat and electricity. Ductile means that an element has the ability to be drawn into a wire. Copper is used in wiring because it is both ductile and conductive. Malleable means that an element has the ability to be hammered into thin sheets while luster means the element is shiny. Silver and gold are both malleable and lustrous, excellent properties for using these elements in jewelry. Metalloids share some characteristics of both metals and nonmetals. For example, silicon has luster and looks like a metal but does not conduct heat or electricity like a metal. Silicon is classified as a semi-conductor since it will conduct electricity better than a nonmetal. The properties of silicon make it an excellent choice for use in electronic devices.

Table 1: Lead, Tin, Carbon, Silicon

1) Take a magnet and pass over each element. Record results into table below.
2) Take a conductivity tester and test each element. Record results into table.
3) Take the strips of lead and tin. Gently bend each. Do not break them! Which is more malleable: lead or tin? _______ Lead ________

<table>
<thead>
<tr>
<th>Element</th>
<th>Color</th>
<th>State (S,L,G)</th>
<th>Metal, Metalloid</th>
<th>Magnetic Yes or No</th>
<th>Conductive Yes or No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lead</td>
<td>SilverGray</td>
<td>S</td>
<td>Metal Nonmetal</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Tin</td>
<td>ShinyGray</td>
<td>S</td>
<td>Metal</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Carbon</td>
<td>Black</td>
<td>S</td>
<td>Nonmetal</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Silicon</td>
<td>DarkGray</td>
<td>S</td>
<td>Metalloid</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Table 2: Iron, Zinc, Nickel, Copper

1) Take a magnet and pass over each element. Record results into table below.
2) Take a conductivity tester and test each element. Record results into table.
3) Take the strips of iron and zinc. Gently bend each. Do not break them! Which is more malleable: iron or zinc? _______ Zinc ________

<table>
<thead>
<tr>
<th>Element</th>
<th>Color</th>
<th>State (S,L,G)</th>
<th>Metal, Metalloid</th>
<th>Magnetic Yes or No</th>
<th>Conductive Yes or No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iron</td>
<td>GrayBlack</td>
<td>S</td>
<td>Metal</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Zinc</td>
<td>LightGray</td>
<td>S</td>
<td>Metal</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Nickel</td>
<td>Silver</td>
<td>S</td>
<td>Metal</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Copper</td>
<td>Copper</td>
<td>S</td>
<td>Metal</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>

4) What is meant by the word “ductile”? ______ drawn into a wire ____________
5) Which element appears to be very ductile? copper
6) Are the elements in the same period or family? period
7) Which element appears prone to rusting? iron

Table 3: Sulfur, Aluminum, Silicon, Magnesium
1) What is meant by “luster”? shiny
2) Which element has a high degree of luster? aluminum
3) Which element appears to be most nonmetallic? sulfur
4) Carefully run a magnetic across the outside of the container. Check if the element follows the magnet. Record results into table below. Do not open the containers. Observe and record color and state of element. Classify.

<table>
<thead>
<tr>
<th>Element</th>
<th>Color</th>
<th>State (S,L,G)</th>
<th>Magnetic Yes or No</th>
<th>Metal, Nonmetal, Metalloid?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sulfur</td>
<td>Yellow</td>
<td>S</td>
<td>No</td>
<td>Nonmetal</td>
</tr>
<tr>
<td>Aluminum</td>
<td>Silver</td>
<td>S</td>
<td>No</td>
<td>Metal</td>
</tr>
<tr>
<td>Silicon</td>
<td>Silver Gray</td>
<td>S</td>
<td>No</td>
<td>Metalloid</td>
</tr>
<tr>
<td>Magnesium</td>
<td>Silver Gray</td>
<td>S</td>
<td>No</td>
<td>Metal</td>
</tr>
</tbody>
</table>

Table 4: Cadmium, Mercury, Zinc
1) Which element is liquid at room temperature? mercury
2) Are these elements in the same period or same family? family
3) Would these elements be classified as metals or metalloids? metals
4) Which element appears to be most lustrous? mercury

Table 5: Helium, Nitrogen, Oxygen
1) Would these elements be classified as metals or nonmetals? nonmetals
2) Which of these elements are in the same period? nitrogen, oxygen
3) What state are these elements in at room temperature? gas

Table 6: Hydrogen, Nickel, Argon, Gallium
1) Which elements appear to be metals? nickel, gallium
2) Which elements appear to be nonmetals? hydrogen, argon

Conclusion:
1) An element is ductile if it can be drawn into a wire.
2) Elements that are malleable can be hammered into thin sheets.
3) What two properties of copper make it desirable for use in wiring?
   conduct electricity and ductile (any order)
4) What two properties of silver and gold are desirable for use in making jewelry?
   malleable and lustrous (any order)
5) What class of elements are brittle and poor conductors of heat? nonmetals
6) All metals are magnetic. Circle your choice: True or False
7) Most metals are solids (solids, liquids or gases) at room temperature.
8) Most nonmetals are gases (solids, liquids or gases) at room temperature.
9) Copper is sometimes coated on the bottom of cookware. What property of copper makes it desirable for this use? conducts heat

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Metals, Nonmetals and Metalloids Lab Quiz

NAME: __________________________ DATE: __________ PERIOD: ______

1) _______________________ can be drawn into a wire.

2) _______________________ can be hammered into thin sheets.

3) What two properties of copper make it desirable for use in wiring?
   _______________________________ and ________________________________

4) What two properties of silver and gold are desirable for use in making jewelry?
   _______________________________ and ________________________________

5) _______________________ elements are typically malleable and lustrous.

6) _______________________ elements are typically colorful and exists in various states.

7) Most metals are ____________ (solids, liquids or gases) at room temperature.

8) Most nonmetals are ____________ (solids, liquids or gases) at room temperature.

9) Copper is sometimes coated on the bottom of cookware. What property of copper makes it desirable for this use?
   ________________________________

Word Bank:
- Malleable
- Ductile
- Conducts Heat
- Conducts Electricity
- Brittle
- Lustrous
- Dull
- Nonconductive
- Metallic
- Nonmetallic
- Metalloids

May use word more than once!
Metals, Nonmetals and Metalloids Lab Make-up

NAME: ____________________________ DATE: __________ PERIOD: ______

Background:
The periodic table can be classified into metals, nonmetals and metalloids. The characteristics of these groups vary greatly. Metals tend to be ductile, malleable, have a metallic luster and are conductors of heat and electricity. Nonmetals tend to be non-lustrous, brittle and poor conductors of heat and electricity. Ductile means that an element has the ability to be drawn into a wire. Copper is used in wiring because it is both ductile and conductive. Malleable means that an element has the ability to be hammered into thin sheets while luster means the element is shiny. Silver and gold are both malleable and lustrous, excellent properties for using these elements in jewelry. Metalloids share some characteristics of both metals and nonmetals. For example, silicon has luster and looks like a metal but does not conduct heat or electricity like a metal. Silicon is classified as a semi-conductor since it will conduct electricity better than a nonmetal. The properties of silicon make it an excellent choice for use in electronic devices.

Table 1: Lead, Tin, Carbon, Silicon
1) Take a magnet and pass over each element. Record results into table below.
2) Take a conductivity tester and test each element. Record results into table.
3) Take the strips of lead and tin. Gently bend each. Do not break them! Which is more malleable: lead or tin? _______Lead___________

<table>
<thead>
<tr>
<th>Element</th>
<th>Color</th>
<th>State</th>
<th>Metal, Metalloid</th>
<th>Magnetic</th>
<th>Conductive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lead</td>
<td>SilverGray</td>
<td>(S,L,G)</td>
<td>Nonmetal</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Tin</td>
<td>ShinyGray</td>
<td>(S,L,G)</td>
<td>Nonmetal</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Carbon</td>
<td>Black</td>
<td>(S,L,G)</td>
<td>Nonmetal</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Silicon</td>
<td>DarkGray</td>
<td>(S,L,G)</td>
<td>Nonmetal</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Table 2: Iron, Zinc, Nickel, Copper
1) Take a magnet and pass over each element. Record results into table below.
2) Take a conductivity tester and test each element. Record results into table.
3) Take the strips of iron and zinc. Gently bend each. Do not break them! Which is more malleable: iron or zinc? __________Zinc______________

<table>
<thead>
<tr>
<th>Element</th>
<th>Color</th>
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<th>Magnetic</th>
<th>Conductive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iron</td>
<td>GrayBlack</td>
<td>(S,L,G)</td>
<td>Nonmetal</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Zinc</td>
<td>LightGray</td>
<td>(S,L,G)</td>
<td>Nonmetal</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Nickel</td>
<td>Silver</td>
<td>(S,L,G)</td>
<td>Nonmetal</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Copper</td>
<td>Copper</td>
<td>(S,L,G)</td>
<td>Nonmetal</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>

4) What is meant by the word “ductile”?

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5) Which element appears to be very ductile? __________ copper
6) Are the elements in the same period or family? __________________________
7) Which element appears prone to rusting? __________ iron

Table 3: Sulfur, Aluminum, Silicon, Magnesium
1) What is meant by “luster”? ________________________________
2) Which element has a high degree of luster? ________________ aluminum
3) Which element appears to be most nonmetallic? _________________________
4) Carefully run a magnetic across the outside of the container. Check if the element follows the magnet. Record results into table below. Do not open the containers. Observe and record color and state of element. Classify.

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<tr>
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</thead>
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<tr>
<td>Magnesium</td>
<td>Silver Gray</td>
<td></td>
<td>No</td>
<td></td>
</tr>
</tbody>
</table>

Table 4: Cadmium, Mercury, Zinc
1) Which element is liquid at room temperature? __________________________
2) Are these elements in the same period or same family? ____________________
3) Would these elements be classified as metals or metalloids? ________________
4) Which element appears to be most lustrous? ________________ mercury

Table 5: Helium, Nitrogen, Oxygen
1) Would these elements be classified as metals or nonmetals? ________________
2) Which of these elements are in the same period? _________________________
3) What state are these elements in at room temperature? ___________________

Table 6: Hydrogen, Nickel, Argon, Gallium
1) Which elements appear to be metals? ________________ nickel, gallium
2) Which elements appear to be nonmetals? ________________ hydrogen, argon

Conclusion:
1) An element is ______________________ if it can be drawn into a wire.
2) Elements that are ______________________ can be hammered into thin sheets.
3) What two properties of copper make it desirable for use in wiring?
   ______________________ and ______________________
4) What two properties of silver and gold are desirable for use in making jewelry?
   ______________________ ______________________
5) What class of elements are brittle and poor conductors of heat? ________________
6) All metals are magnetic. Circle your choice: True or False___________________
7) Most metals are ________________ (solids, liquids or gases) at room temperature.
8) Most nonmetals are ________________ (solids, liquids or gases) at room temperature.
9) Copper is sometimes coated on the bottom of cookware. What property of copper makes it desirable for this use? __________________________
Types of Chemical Reactions Lab

NAME: ____________________________ DATE: __________ PERIOD: _______

Background:
A chemical reaction often gives visible clues. The release of a gas, formation of a solid,
and changes in heat or color sometimes indicate that a reaction has occurred.

<table>
<thead>
<tr>
<th>Reaction Type</th>
<th>Reaction Class</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Double Replacement</td>
<td></td>
<td>“Compound + Compound”</td>
</tr>
<tr>
<td>“DR”</td>
<td>Acid - Base</td>
<td></td>
</tr>
<tr>
<td></td>
<td>OR Precipitation</td>
<td></td>
</tr>
<tr>
<td>Single Replacement</td>
<td>Redox</td>
<td>“Element + Compound”</td>
</tr>
<tr>
<td>“SR”</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Complete Combustion</td>
<td>Redox</td>
<td>“CxHy + O2 → CO2 + H2O”</td>
</tr>
<tr>
<td>“CC”</td>
<td></td>
<td>Blue flame</td>
</tr>
<tr>
<td>Incomplete Combustion</td>
<td>Redox</td>
<td>“CxHy + O2 → CO + H2O”</td>
</tr>
<tr>
<td>“IC”</td>
<td></td>
<td>Yellow flame</td>
</tr>
<tr>
<td>Decomposition</td>
<td>Redox</td>
<td>“one reactant”</td>
</tr>
<tr>
<td>“D”</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Synthesis</td>
<td>Redox</td>
<td>“one product”</td>
</tr>
<tr>
<td>“S”</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Complete a balanced equation for each of the following stations. Give reaction type &
class and the evidence for each reaction. Evidence Choices: heat, light, bubbles, solid.

1) Add a few drops of potassium iodide, KI, to a few drops of lead (II) nitrate,
Pb(NO3)2.
Type ______ Evidence ___________ Class _______
Balanced equation: ____KI + ____Pb(NO3)2 →

2) Add a few drops of vinegar (5% HC2H3O2) to a pea size amount of chalk, (CaCO3).
Type ______ Evidence ___________ Class _______
Balanced equation: ____HC2H3O2 + ____CaCO3 →

3) Using crucible tongs, place a small strip of magnesium ribbon (Mg) into a flame. DO
    NOT LOOK DIRECTLY INTO THE FLAME WHEN THE REACTION OCCURS!
Type ______ Evidence ___________ Class _______
Balanced equation: ____Mg + ____O2 →

4) Light a Bunsen burner and adjust the barrel so that there is insufficient oxygen.
Observe and write the balanced equation for the burning of methane (CH4) gas.
Type ______ Evidence ___________ Class _______
Balanced equation: ____CH4 + ____O2 →

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5) Light a Bunsen burner and adjust the barrel so that there is sufficient oxygen. Observe and write the balanced equation for the burning of the methane gas.

Type ______ Evidence __________ Class _______
Balanced equation: ____CH₄ + ____O₂ →

6) Add a pea size amount of Alka-Seltzer into a small test tube and add 3 milliliters of water. The water only acts as a medium in which the reaction between the two ingredients can occur. Alka-Seltzer is made of sodium bicarbonate (NaHCO₃) and citric acid (HC₆H₇O₇).

Type ______ Evidence __________ Class _______
Balanced equation: ____NaHCO₃ + ____HC₆H₇O₇ →

7) Add a few drops of sodium hydroxide, NaOH, with a few drops of cupric nitrate, Cu(NO₃)₂.

Type ______ Evidence __________ Class _______
Balanced equation: ____NaOH + ____Cu(NO₃)₂ →

8) Add several drops of hydrochloric acid, HCl, to a small strip of magnesium ribbon.

Type ______ Evidence __________ Class _______
Balanced equation: ____HCl + ____Mg →

9) Add a few drops of silver nitrate, AgNO₃, to a few drops of sodium chloride, NaCl.

Type ______ Evidence __________ Class _______
Balanced equation: ____AgNO₃ + ____NaCl →

10) Add several drops of sulfuric acid, H₂SO₄, to a few small pieces of zinc metal.

Type ______ Evidence __________ Class _______
Balanced equation: ____H₂SO₄ + ____Zn →

11) Place a pea size amount of baking soda, NaHCO₃, in a test tube and add 1-2 milliliters of vinegar (5% HC₂H₃O₂).

Type ______ Evidence __________ Class _______
Balanced equation: ____NaHCO₃ + ____HC₂H₃O₂ →

12) Observe the Hoffman apparatus, which splits water using electric current.

Type ______ Evidence __________ Class _______
Balanced equation: ____H₂O →

Study the gas collecting in tube #1 and the gas collecting in tube #2, using the balanced equation written above which tube is collecting oxygen and which is collecting hydrogen. Explain your reasoning.
Teacher Notes: Types of Reactions

This lab is a variation of the Types of Reactions Lab in Volume 3. The reason for the modification was to have a form that is user friendly to lower levels of chemistry.

Set-up:
There are 12 stations for this lab and the lab will take approximately one and hour to set up the first time through. The following year the lab should only take 15-25 minutes to set up. The dropping bottles could be made and stored as a kit for the following year. The equipment and glassware are standard items in a chemistry room and should be easy to obtain and set out. Instead of beakers containing the substances plastic chemical bottles could be used instead. This will allow for all the chemicals to be in either a dropping bottle or a plastic bottle and could be stored as a kit.

Station 1
Test tube rack, test tube, waste beaker, dropper bottles of KI and Pb(NO₃)₂
Station 2
Test tube rack, test tube, waste beaker, dropper bottle of vinegar and beaker containing calcium carbonate and a spatula
Station 3
Small beaker with pre-cut Mg strips, tongs, striker, waste beaker, Bunsen burner
Station 4
Striker, Bunsen burner
Station 5
Striker, Bunsen burner
Station 6
Test tube rack, test tube, waste beaker, 10 mL graduated cylinder and beaker containing a mixture of baking soda/citric acid and a spatula
Making the mixture using chemicals from the storeroom cuts down on the cost of using actual Alka-Seltzer ® tablets.
Station 7
Test tube rack, test tube, waste beaker, dropper bottles of NaOH and Cu(NO₃)₂
Station 8
Test tube rack, test tube, waste beaker, dropper bottle of HCl and small beaker containing pre-cut strips of Mg ribbon
Station 9
Test tube rack, test tube, waste beaker, dropper bottles of AgNO₃ and NaCl
Station 10
Test tube rack, test tube, waste beaker, dropper bottle of H₂SO₄ and small beaker containing small pieces of mossy zinc
Station 11
Test tube rack, test tube, waste beaker, dropper bottle of vinegar and small beaker containing baking soda and a spatula
Station 12

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Hoffman Apparatus with tubes labeled #1 and #2

**Teaching Tips:**
This lab should be done after students have determined reaction types, predicted products and written balanced equations.

The students enjoy this lab since there are many things to see. The students should be very familiar with lighting and adjusting a Bunsen burner before doing this lab. Students must be warned about looking directly into the burning of the magnesium ribbon. This could be done instead as a demonstration for the students. If not done as a demonstration, be sure you are monitoring this station closely. Students should also be told not to touch the Hoffman Apparatus and to only observe the reaction.

At the end of the period collect the gases from the apparatus and demonstrate the test for hydrogen and oxygen gas. Holding the hydrogen test tube inverted and placing a lit splint under the mouth should demonstrate to students that the gas is lighter than air and that it pops when it reacts with the oxygen in the air. Holding the oxygen test tube upright and placing a glowing splint into the test tube should demonstrate to students that the oxygen is heavier than air and that the splint bursts into a flame when in the presence of pure oxygen gas.

For simplicity the citric acid in the reaction is treated like a monoprotic acid. Further discussion on polyprotic acids and the actual number of ionizable hydrogen ions from citric acid could be done as a follow up.

Although some of the test tubes could have been flushed down a sink, a waste container at each station provides consistency in disposal and cleaning up.
Types of Chemical Reactions Lab

Background:
A chemical reaction often gives visible clues. The release of a gas, formation of a solid, and changes in heat or color sometimes indicate that a reaction has occurred.

<table>
<thead>
<tr>
<th>Reaction Type</th>
<th>Reaction Class</th>
<th>Description</th>
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<tbody>
<tr>
<td>Double Replacement “DR”</td>
<td>Acid – Base</td>
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<td>OR Precipitation</td>
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<td>“C_xH_y + O_2 → CO_2 + H_2O” Blue flame</td>
</tr>
<tr>
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</tr>
<tr>
<td>Decomposition “D”</td>
<td>Redox</td>
<td>“one reactant”</td>
</tr>
<tr>
<td>Synthesis “S”</td>
<td>Redox</td>
<td>“one product”</td>
</tr>
</tbody>
</table>

Complete a balanced equation for each of the following stations. Give reaction type & class and the evidence for each reaction. Evidence Choices: heat, light, bubbles, solid.

1) Add a few drops of potassium iodide, KI, to a few drops of lead (II) nitrate, Pb(NO_3)_2.
   Type _DR_ Evid _solid_ Class _P_
   2 KI  + Pb(NO_3)_2 → PbI_2  + 2 KNO_3

2) Add a few drops of vinegar (5% HC_2H_3O_2) to a pea size amount of chalk, (CaCO_3).
   Type _DR/D_ Evid _gas_ Class _AB/RD_
   2 HC_2H_3O_2  + CaCO_3 → H_2CO_3  +  Ca(C_2H_3O_2)_2
   H_2CO_3 → H_2O + CO_2

3) Using crucible tongs, place a small strip of magnesium ribbon (Mg) into a flame.
   DO NOT LOOK DIRECTLY INTO THE FLAME WHEN THE REACTION OCCURS!
   Type _S_ Evid _light/heat_ Class _RD_
   2 Mg  + O_2 → 2 MgO

4) Light a Bunsen burner and adjust the barrel so that there is insufficient oxygen.
   Observe and write the balanced equation for the burning of methane (CH_4) gas.
   Type _IC_ Evid _light/heat_ Class _RD_
   2 CH_4  + 3 O_2 → 2 CO  +  4 H_2O

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5) Light a Bunsen burner and adjust the barrel so that there is sufficient oxygen. Observe and write the balanced equation for the burning of the methane gas.

Type \[ \text{CC} \] Evid \( \text{light/heat} \) Class \( \text{RD} \)

\[
\text{CH}_4 + 2 \text{O}_2 \rightarrow \text{CO}_2 + 2 \text{H}_2\text{O}
\]

6) Add a pea size amount of Alka-Seltzer into a small test tube and add 3 milliliters of water. The water only acts as a medium in which the reaction between the two ingredients can occur. Alka-Seltzer is made of sodium bicarbonate (\( \text{NaHCO}_3 \)) and citric acid (\( \text{H}_3\text{C}_6\text{H}_7\text{O}_7 \)).

Type \[ \text{DR/D} \] Evid \( \text{gas} \) Class \( \text{AB/RD} \)

\[
\text{NaHCO}_3 + \text{H}_3\text{C}_6\text{H}_7\text{O}_7 \rightarrow \text{H}_2\text{CO}_3 + \text{NaC}_6\text{H}_7\text{O}_7
\]
\[
\text{H}_2\text{CO}_3 \rightarrow \text{H}_2\text{O} + \text{CO}_2
\]

7) Add a few drops of sodium hydroxide, \( \text{NaOH} \), with a few drops of cupric nitrate, \( \text{Cu(NO}_3\text{)}_2 \).

Type \[ \text{DR} \] Evid \( \text{solid} \) Class \( \text{P} \)

\[
2 \text{NaOH} + \text{Cu(NO}_3\text{)}_2 \rightarrow \text{Cu(OH)}_2 + 2 \text{NaNO}_3
\]

8) Add several drops of hydrochloric acid, \( \text{HCl} \), to a small strip of magnesium ribbon.

Type \[ \text{SR} \] Evid \( \text{gas} \) Class \( \text{RD} \)

\[
2 \text{HCl} + \text{Mg} \rightarrow \text{MgCl}_2 + \text{H}_2
\]

9) Add a few drops of silver nitrate, \( \text{AgNO}_3 \), to a few drops of sodium chloride, \( \text{NaCl} \).

Type \[ \text{DR} \] Evid \( \text{solid} \) Class \( \text{P} \)

\[
\text{AgNO}_3 + \text{NaCl} \rightarrow \text{AgCl} + \text{NaNO}_3
\]

10) Add several drops of sulfuric acid, \( \text{H}_2\text{SO}_4 \), to a few small pieces of zinc metal.

Type \[ \text{SR} \] Evid \( \text{gas} \) Class \( \text{RD} \)

\[
\text{H}_2\text{SO}_4 + \text{Zn} \rightarrow \text{ZnSO}_4 + \text{H}_2
\]

11) Place a pea size amount of baking soda, \( \text{NaHCO}_3 \), in a test tube and add 1-2 milliliters of vinegar (5% \( \text{HC}_2\text{H}_3\text{O}_2 \)).

Type \[ \text{DR/D} \] Evid \( \text{gas} \) Class \( \text{AB/RD} \)

\[
\text{NaHCO}_3 + \text{HC}_2\text{H}_3\text{O}_2 \rightarrow \text{H}_2\text{CO}_3 + \text{NaC}_2\text{H}_3\text{O}_2
\]
\[
\text{H}_2\text{CO}_3 \rightarrow \text{H}_2\text{O} + \text{CO}_2
\]

12) Observe the Hoffman apparatus, which splits water using electric current.

Type \[ \text{D} \] Evid \( \text{gas} \) Class \( \text{RD} \)

\[
2 \text{H}_2\text{O} \rightarrow 2 \text{H}_2 + \text{O}_2
\]

*The tube with the greatest amount of gas produced is the tube containing hydrogen because in the balanced equation 2 moles of hydrogen is produced to every 1 mole of oxygen.*
Types of Chemical Reactions Lab Quiz

Balance the following reactions by placing the appropriate stoichiometric coefficient into each blank.

1) \( _____C_2H_6 + _____O_2 \rightarrow _____CO_2 + _____H_2O \)

2) \( _____Mg + _____O_2 \rightarrow _____MgO \)

3) \( _____KClO_3 \rightarrow _____KCl + _____O_2 \)

4) \( _____CH_4 + _____O_2 \rightarrow _____CO + _____H_2O \)

5) \( _____CuCl_2 + _____Al \rightarrow _____AlCl_3 + _____Cu \)

6) \( _____Pb(NO_3)_2 + _____KI \rightarrow _____PbI_2 + _____KNO_3 \)

Give the reaction type by placing one of the following choices into the blank.
DR Double Replacement
SR Single Replacement
D Decomposition
S Synthesis
IC Incomplete Combustion
CC Complete Combustion

7) \( _____CO_2 + H_2O \rightarrow \)

8) \( _____CaCO_3 \rightarrow \)

9) \( _____AgNO_3 + NaCl \rightarrow \)

10) \( _____F_2 + NaI \rightarrow \)

11) \( _____C_3H_8 + O_2 \rightarrow CO + H_2O \)

Give the class by placing one of the following choices into the blank.
A-B Acid-Base
Prec Precipitation
Redox Reduction-Oxidation

12) \( _____ H_2 + O_2 \rightarrow H_2O \)

13) \( _____ NaOH + HCl \rightarrow H_2O + NaCl \)

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Types of Chemical Reactions Lab Make-up

NAME:______________________________ DATE:________________ PERIOD:_______

Background:
A chemical reaction often gives visible clues. The release of a gas, formation of a solid, and changes in heat or color sometimes indicate that a reaction has occurred.

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</table>

Complete a balanced equation for each of the following stations. Give reaction type & class and the evidence for each reaction. Evidence Choices: heat, light, bubbles, solid.

1) Add a few drops of potassium iodide, KI, to a few drops of lead (II) nitrate, Pb(NO₃)₂.
Type ______ Evidence _________ Class _______ A yellow solid forms.
Balanced equation: ____KI + ____Pb(NO₃)₂ ➞
2) Add a few drops of vinegar (5% HC₂H₃O₂) to a pea size amount of chalk, (CaCO₃).
Type ______ Evidence _________ Class _______ Many bubbles are produced.
Balanced equation: ____HC₂H₃O₂ + ____CaCO₃ ➞
3) Using crucible tongs, place a small strip of magnesium ribbon (Mg) into a flame. DO NOT LOOK DIRECTLY INTO THE FLAME WHEN THE REACTION OCCURS!
Type ______ Evidence _________ Class _______ The Mg burns with a bright light.
Balanced equation: ____Mg + ____O₂ ➞
4) Light a Bunsen burner and adjust the barrel so that there is insufficient oxygen.
Observe and write the balanced equation for the burning of methane (CH₄) gas.
Type ______ Evidence _________ Class _______ Gas burns producing a yellow flame.
Balanced equation: ____CH₄ + ____O₂ ➞
5) Light a Bunsen burner and adjust the barrel so that there is sufficient oxygen. Observe and write the balanced equation for the burning of the methane gas.

Type _____ Evidence _______ Class _______ Gas burns producing a blue flame.
Balanced equation: ____CH₄ + ____O₂ →

6) Add a pea size amount of Alka-Seltzer into a small test tube and add 3 milliliters of water. The water only acts as a medium in which the reaction between the two ingredients can occur. Alka-Seltzer is made of sodium bicarbonate (NaHCO₃) and citric acid (HC₆H₇O₇).

Type _____ Evidence _______ Class _______ Many bubbles form.
Balanced equation: ____NaHCO₃ + ____HC₆H₇O₇ →

7) Add a few drops of sodium hydroxide, NaOH, with a few drops of cupric nitrate, Cu(NO₃)₂.

Type _____ Evidence __________ Class _______ A precipitate forms.
Balanced equation: ____NaOH + ____Cu(NO₃)₂ →

8) Add several drops of hydrochloric acid, HCl, to a small strip of magnesium ribbon.

Type _____ Evidence __________ Class _______ Many bubbles form.
Balanced equation: ____HCl + ____Mg →

9) Add a few drops of silver nitrate, AgNO₃, to a few drops of sodium chloride, NaCl.

Type _____ Evidence __________ Class _______ A white precipitate forms.
Balanced equation: ____AgNO₃ + ____NaCl →

10) Add several drops of sulfuric acid, H₂SO₄, to a few small pieces of zinc metal.

Type _____ Evidence __________ Class _______ Many bubbles form.
Balanced equation: ____H₂SO₄ + ____Zn →

11) Place a pea size amount of baking soda, NaHCO₃, in a test tube and add 1-2 milliliters of vinegar (5% HC₂H₃O₂).

Type _____ Evidence __________ Class _______ Many bubbles form.
Balanced equation: ____NaHCO₃ + ____HC₂H₃O₂ →

12) Observe the Hoffman apparatus, which splits water using electric current.

Type _____ Evidence __________ Class _______
Tube #1 has 15 mL. Tube #2 has 30 mL of gas.
Balanced equation: ____H₂O →

Study the gas collecting in tube #1 and the gas collecting in tube #2, using the balanced equation written above which tube is collecting oxygen and which is collecting hydrogen. Explain your reasoning.

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Fun with Polymers Lab

NAME: ___________________________ DATE: ___________ PERIOD: _______

Background:
Polymers are large molecules made up of repeating units called monomers. The word polymer means many members or parts. Cellulose, wool, starch, protein, silk, cotton and fiber are examples of natural polymers. Teflon, plastic, nylon, acrylic, polyurethane, polyester, polystyrene, rubber and paint are all examples of synthetic polymers. Man-made polymers can be made by addition reactions, condensation reactions and cross-linking. In addition reactions monomer units combine to make long chain polymers. In condensation reactions a small molecule or water unit is produce along with the long chain polymer. Cross-linking can occur during addition or condensation reactions when a molecule or atom links the polymer chains together. Cross-linking can also occur when a molecule is added to polymer chains.

Addition Reaction: Production of Polyethylene
\[
\text{CH}_2=\text{CH}_2 + \text{CH}_2=\text{CH}_2 + \text{CH}_2=\text{CH}_2 \rightarrow -\text{CH}_2-\text{CH}_2-\text{CH}_2-\text{CH}_2-\text{CH}_2-
\]
Ethylene monomers Polyethylene chain

Condensation Reaction: Production of Nylon
\[
\text{H}_2\text{NCH}_2(\text{CH}_2)_4\text{COOH} + \text{H}_2\text{NCH}_2(\text{CH}_2)_4\text{COOH} \rightarrow [-\text{CH}_2(\text{CH}_2)_4\text{CONH-}]_x + \text{H}_2\text{O}
\]
6-aminohexanoic acid monomers nylon polymer

Cross-linking Reaction: Production of Slime

PVA---PVA---PVA---PVA---PVA---PVA---PVA---PVA
Borate Borate Borate
PVA---PVA---PVA---PVA---PVA---PVA---PVA---PVA
Long polymer chains get linked together by an added molecule or atom. PVA, polyvinyl alcohol, is a long carbon based polymer chain.

In today’s lab activity new polymer products will be made by cross-linking polymer chains. The polymer chains before cross-linking behave more like a liquid but after cross-linking behave more like a solid. This is because the chains have been linked together and are no longer free to slide past each other.

Procedure & Observations:

Gluep
Place 13 mL of glue, 26 mL of water and 9 mL of borax solution to a paper cup. Stir with a wooden stick. If available, 2 drops of food coloring may be added to the cup while stirring.

Observation: ___________________________
**Gluep**
Place 20 mL of glue and 10 mL of borax into a paper cup. Stir with a wooden stick. If available, 2 drops of food coloring may be added to the cup while stirring.

Observation: ________________________________________________________

**Understanding Gluep:**
Glue contains long chains of the polymer polyvinyl acetate which slip past each other while in glue, when Borax (sodium borate) is added to glue the sodium borate links the polyvinyl acetate chains together. The chains are now unable to slip past each other and the Gluep behaves more like a solid.

**Slime**
Obtain 2 graduated cylinders. Measure 5 mL of 4% sodium borate solution into one cylinder and 25 mL of 4% polyvinyl alcohol solution into the other cylinder. Pour both solutions into a paper cup and stir with a wooden stick. If available, 2 drops of food coloring may be added to the cup while stirring.

Pull the slime apart. Will the slime stretch? _______________________________
Roll the slime into a ball. Will the slime bounce? ____________________________
Place the slime onto a table. Hit the slime with your hand. Does it splatter? ________
Leave the slime on the table for several minutes. Does some of the slime start to flow like a liquid? __________________________________________________________

A Non-Newtonian fluid is a fluid that will stretch under low pressure, break under high pressure, bounces off of hard surfaces and flows like a liquid when left alone. Does slime behave like a non-Newtonian fluid? _____________________________

**Understanding Slime:**
The sodium borate cross-links the long chains of polyvinyl alcohol. The borate acts like a rung on a ladder.

**Conclusion:**
1) What word means many repeating units? ______________________________
2) Cellulose, starch and protein are examples of _______________ polymers.
3) Teflon, polyester, and nylon are examples of _______________ polymers.
4) Adding ethylene units together to make polyethylene chains is an example of an/a _______________ reaction.
5) Adding monomers together to make a polymer chain and a water molecule is an example of an/a _______________ reaction.
6) The addition of a molecule or element to link polymer chains together is an example of _______________________.
7) _______________ is produced when polyvinyl acetate is linked by sodium borate.
8) _______________ is produced when PVA chains are linked by sodium borate.
Teacher Notes: Fun with Polymers Lab

At each lab station:
2 50-mL graduated cylinders
Brush to clean graduated cylinders

At a central location:
4 Liter plastic bottles of 4% sodium borate solution
4 Liter plastic bottles of 4% PVA solution
Glue    Gallon size container or several smaller containers for each lab table
Large box of Wood tongue depressors
Small paper cups   4-5 Boxes depending on number of students
Food coloring        2-3 Boxes depending on number of students
Small plastic zip close bags (If you decide to allow students to take their product.)

Teaching Tips:
This lab is intended to introduce polymers and the types of polymer reactions. The student should read the background and answer conclusion questions #1-6 before being dismissed back to the lab area.

Remind students that the lab area should be thoroughly cleaned when they are finished. Marking one graduated cylinder PVA and the other cylinder borate will cut down on the use of pouring both solutions into the same cylinder and forming slime inside the cylinder which can be a little messy.

The glue, food coloring, plastic bags and paper cups could be placed onto an extra credit lab supply list and collected during the year in order to have some of the supplies for this lab activity.

This is a very fun day for both the teacher and the students.
Fun with Polymers Lab

NAME: __________________________  DATE: _____________  PERIOD: ______

Background:
Polymers are large molecules made up of repeating units called monomers. The word polymer means many members or parts. Cellulose, wool, starch, protein, silk, cotton and fiber are examples of natural polymers. Teflon, plastic, nylon, acrylic, polyurethane, polyester, polystyrene, rubber and paint are all examples of synthetic polymers. Man-made polymers can be made by addition reactions, condensation reactions and cross-linking. In addition reactions monomer units combine to make long chain polymers. In condensation reactions a small molecule or water unit is produce along with the long chain polymer. Cross-linking can occur during addition or condensation reactions when a molecule or atom links the polymer chains together. Cross-linking can also occur when a molecule is added to polymer chains.

**Addition Reaction: Production of Polyethylene**

\[
CH_2=CH_2 + CH_2=CH_2 + CH_2=CH_2 \rightarrow -CH_2-CH_2-CH_2-CH_2-CH_2-
\]

Ethylene monomers  Polyethylene chain

**Condensation Reaction: Production of Nylon**

\[
H_2NCH_2(CH_2)_4COOH + H_2NCH_2(CH_2)_4COOH \rightarrow [-CH_2(CH_2)_4CONH-]_x + H_2O
\]

6-aminohexanoic acid monomers  nylon polymer

**Cross-linking Reaction: Production of Slime**

PVA---PVA---PVA---PVA---PVA---PVA---PVA---PVA

Borate  Borate  Borate

PVA---PVA---PVA---PVA---PVA---PVA---PVA---PVA

Long polymer chains get linked together by an added molecule or atom. PVA, polyvinyl alcohol, is a long carbon based polymer chain.

In today's lab activity new polymer products will be made by cross-linking polymer chains. The polymer chains before cross-linking behave more like a liquid but after cross-linking behave more like a solid. This is because the chains have been linked together and are no longer free to slide past each other.

Procedure & Observations:

**Gluep**

Place 13 mL of glue, 26 mL of water and 9 mL of borax solution to a paper cup. Stir with a wooden stick. If available, 2 drops of food coloring may be added to the cup while stirring.

Observation: *Addition of borax change properties of material to become more solid-like.*

*Answers vary.*
Gluep
Place 20 mL of glue and 10 mL of borax into a paper cup. Stir with a wooden stick. If available, 2 drops of food coloring may be added to the cup while stirring.

Observation: The gluep made without water is a little more rigid. Answers vary.

Understanding Gluep:
Glue contains long chains of the polymer polyvinyl acetate which slip past each other while in glue, when Borax (sodium borate) is added to glue the sodium borate links the polyvinyl acetate chains together. The chains are now unable to slip past each other and the Gluep behaves more like a solid.

Slime
Obtain 2 graduated cylinders. Measure 5 mL of 4% sodium borate solution into one cylinder and 25 mL of 4% polyvinyl alcohol solution into the other cylinder. Pour both solutions into a paper cup and stir with a wooden stick. If available, 2 drops of food coloring may be added to the cup while stirring.

Pull the slime apart. Will the slime stretch? ______Yes, too far it pulls apart.______
Roll the slime into a ball. Will the slime bounce? _____Yes, but sometimes sticks.___
Place the slime onto a table. Hit the slime with your hand. Does it splatter? ___No___
Leave the slime on the table for several minutes. Does some of the slime start to flow like a liquid? ___Yes, around the edges._______________________________

A Non-Newtonian fluid is a fluid that will stretch under low pressure, break under high pressure, bounces off of hard surfaces and flows like a liquid when left alone. Does slime behave like a non-Newtonian fluid? _____Yes______________________

Understanding Slime:
The sodium borate cross-links the long chains of polyvinyl alcohol. The borate acts like a rung on a ladder.

Conclusion:
1) What word means many repeating units? ____polymer___________________
2) Cellulose, starch and protein are examples of __natural__________ polymers.
3) Teflon, polyester, and nylon are examples of synthetic (man-made) polymers.
4) Adding ethylene units together to make polyethylene chains is an example of an/a _addition_______ reaction.
5) Adding monomers together to make a polymer chain and a water molecule is an example of an/a __condensation______ reaction.
6) The addition of a molecule or element to link polymer chains together is an example of __cross-linking______.
7) __Gluep______ is produced when polyvinyl acetate is linked by sodium borate.
8) __Slime______ is produced when PVA chains are linked by sodium borate.

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Fill in the blank. Use the word bank below, not all words will be used.
1) ______________ occurs when an atom or molecule holds two polymer chains together.
2) A ______________ reaction produces a polymer chain and a small molecule or water molecule.
3) A ______________ reaction produces polymer chains by combining monomer units.
4) ______________ is produce when polyvinyl alcohol is cross-linked with sodium borate.
5) ______________ is produced when polyvinyl acetate is cross-linked with sodium borate.
6) Wool, silk and cellulose are examples of ______________ polymers.
7) Plastic, nylon and polystyrene are examples of ______________ polymers.
8) Reaction A is an example of a ____________________ reaction.
9) Reaction B is an example of a ____________________ reaction.
10) Reaction C is an example of a ____________________ reaction.

Word Bank: May use word more than once.
condensation
addition
subtraction
cross-linking
gluep
slime
play-dough
natural
synthetic

Reaction A:
\[ \text{CH}_2=\text{CH}_2 + \text{CH}_2=\text{CH}_2 + \text{CH}_2=\text{CH}_2 \rightarrow \text{-CH}_2-\text{CH}_2-\text{CH}_2-\text{CH}_2-\text{CH}_2-\text{CH}_2-\text{CH}_2-\text{CH}_2-\text{CH}_2- \]

Reaction B:
\[ \text{H}_2\text{NCH}_2(\text{CH}_2)_4\text{COOH} + \text{H}_2\text{NCH}_2(\text{CH}_2)_4\text{COOH} \rightarrow \text{-CH}_2(\text{CH}_2)_4\text{CONH-}]_x + \text{H}_2\text{O} \]

Reaction C:
\[ \text{PVA---PVA---PVA---PVA---PVA---PVA---PVA---PVA---PVA} \]

Borate       Borate       Borate
PVA---PVA---PVA---PVA---PVA---PVA---PVA---PVA---PVA---PVA

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Fun with Polymers Lab Make-up

NAME: ____________________________ DATE: ____________ PERIOD: ______

Background:
Polymers are large molecules made up of repeating units called monomers. The word polymer means many members or parts. Cellulose, wool, starch, protein, silk, cotton and fiber are examples of natural polymers. Teflon, plastic, nylon, acrylic, polyurethane, polyester, polystyrene, rubber and paint are all examples of synthetic polymers. Man-made polymers can be made by addition reactions, condensation reactions and cross-linking. In addition reactions monomer units combine to make long chain polymers. In condensation reactions a small molecule or water unit is produce along with the long chain polymer. Cross-linking can occur during addition or condensation reactions when a molecule or atom links the polymer chains together. Cross-linking can also occur when a molecule is added to polymer chains.

Addition Reaction: Production of Polyethylene

\[ \text{CH}_2=\text{CH} + \text{CH}_2=\text{CH}_2 + \text{CH}_2=\text{CH}_2 \rightarrow \text{-CH}_2-\text{CH}_2-\text{CH}_2-\text{CH}_2-\text{CH}_2- \]

Ethylene monomers Polyethylene chain

Condensation Reaction: Production of Nylon

\[ \text{H}_2\text{NCH}_2(\text{CH}_2)_4\text{COOH} + \text{H}_2\text{NCH}_2(\text{CH}_2)_4\text{COOH} \rightarrow \text{[-CH}_2(\text{CH}_2)_4\text{CONH-}]_x + \text{H}_2\text{O} \]

6-aminohexanoic acid monomers nylon polymer

Cross-linking Reaction: Production of Slime

PVA---PVA---PVA---PVA---PVA---PVA---PVA---PVA

Borate Borate Borate

PVA---PVA---PVA---PVA---PVA---PVA---PVA---PVA

Long polymer chains get linked together by an added molecule or atom. PVA, polyvinyl alcohol, is a long carbon based polymer chain.

In today's lab activity new polymer products will be made by cross-linking polymer chains. The polymer chains before cross-linking behave more like a liquid but after cross-linking behave more like a solid. This is because the chains have been linked together and are no longer free to slide past each other.

Procedure & Observations:

Gluep

Place 13 mL of glue, 26 mL of water and 9 mL of borax solution to a paper cup. Stir with a wooden stick. If available, 2 drops of food coloring may be added to the cup while stirring.

Observation: Addition of borax change properties of material to become more solid-like.
**Gluep**
Place 20 mL of glue and 10 mL of borax into a paper cup. Stir with a wooden stick. If available, 2 drops of food coloring may be added to the cup while stirring.

Observation: *The gluep made without water is a little more rigid.*

**Understanding Gluep:**
Glue contains long chains of the polymer polyvinyl acetate which slip past each other while in glue, when Borax (sodium borate) is added to glue the sodium borate links the polyvinyl acetate chains together. The chains are now unable to slip past each other and the Gluep behaves more like a solid.

**Slime**
Obtain 2 graduated cylinders. Measure 5 mL of 4% sodium borate solution into one cylinder and 25 mL of 4% polyvinyl alcohol solution into the other cylinder. Pour both solutions into a paper cup and stir with a wooden stick. If available, 2 drops of food coloring may be added to the cup while stirring.

Pull the slime apart. Will the slime stretch? ______Yes until it pulls apart.____
Roll the slime into a ball. Will the slime bounce? ___Yes_______________________
Place the slime onto a table. Hit the slime with your hand. Does it splatter? ___No__
Leave the slime on the table for several minutes. Does some of the slime start to flow like a liquid? ___Yes, especially around the edges._______________________

A Non-Newtonian fluid is a fluid that will stretch under low pressure, break under high pressure, bounces off of hard surfaces and flows like a liquid when left alone. Does slime behave like a non-Newtonian fluid? ___________________________

**Understanding Slime:**
The sodium borate cross-links the long chains of polyvinyl alcohol. The borate acts like a rung on a ladder.

**Conclusion:**
1) What word means many repeating units? ______________________________
2) Cellulose, starch and protein are examples of ___________ polymers.
3) Teflon, polyester, and nylon are examples of _____________ polymers.
4) Adding ethylene units together to make polyethylene chains is an example of an/a ______________ reaction.
5) Adding monomers together to make a polymer chain and a water molecule is an example of an/a ______________ reaction.
6) The addition of a molecule or element to link polymer chains together is an example of ________________.
7) ___________ is produced when polyvinyl acetate is linked by sodium borate.
8) ___________ is produced when PVA chains are linked by sodium borate.

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